Additionally, pursuant to 37 C.F.R. § 1.97(c)(1), a new information disclosure statement is filed concurrently herewith. Each item of information in this IDS was cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the IDS.

If any additional fees are due, please consider this authorization to charge the deposit account of Coats & Bennett, No. 18-1167.

REMARKS

The present invention comprises an active phased array transmitter (including an array of antenna elements) for the simultaneous transmission of multiple signals with minimal intermodulation distortion between the signals, while maintaining the full directed gain of which the full associated antenna aperture area is capable. The low intermodulation distortion results from restricting each antenna element power amplifier to a single signal. Both the single-signal amplifiers, and effective use of the full gain of the antenna array by utilizing the full aperture thereof, are achieved by sourcing the array with a matrix of beam-formed and phase-shifted signals. That is, the antenna element array is divided into m rows and n columns. Each row is sourced by a plurality of separate signals, placed in phased relationship with each other by a Butler matrix, which directs each signal's radiation to a different angular position. The vertical stacking of an identically configured Butler matrix for each row (with the same signals applied to the same inputs) effectively confines each separate signal to a vertical "fan" pattern, with the fan for each signal extending from the antenna array at a different angle. Additionally, each column (that is, the same n^{th} input of each row's Butler matrix)

is sourced by a beamforming circuit effective to "steer" the signal by concentrating its energy at one of its *m* outputs, or rows. In this configuration, each signal may be directed to a specific one of *n* vertical fans (*i.e.*, a column) via a signal router directing the signal to one of *n* Butler matrix inputs, to place the signal's propagation at a specific (and unique) angle from the antenna array. Additionally, a "spot" of the concentrated signal can be aimed up and down the fan (*i.e.*, a row or position between rows) via the intervening beamformer controls. Claim 1 recites this structure (claims 27 and 34 are analogous):

> 1. A transmitter for simultaneously transmitting *n* different signals in *l* directive beams, said transmitter comprising:
>
> *n* beamformers receiving *n* different signals with each beamformer receiving a signal to be transmitted, each of said beamformers having *m* outputs for each signal to be transmitted, and wherein said *n* beamformers have an *m x n* output array;
>
> *m* passive couplers each operatively connected to said *n* beamformers, wherein each passive coupler has *n* inputs for receiving said *n* different signals to be transmitted simultaneously from said *n* beamformers, each passive coupler having *p* outputs in phased relationship to one another; and
>
> an antenna with an aperture within which a two-dimensional *m* x *p* array of radiating elements are disposed, said radiating elements connected to the outputs of the passive couplers and transmitting said *n* different signals simultaneously in *l* directive beams,
>
> wherein each of said *n* beamformers receives steering control signals for determining the direction of transmission for each of said directive beams.

In this configuration (see Fig. 5), each power amplifier – disposed between the beamformer outputs and the Butler matrix inputs – amplifies only a single signal, virtually eliminating intermodulation distortion. Confining each amplifier to a single signal also allows the use of efficient class-C power amplifiers, operated at or near saturation. Additionally, each signal is transmitted by the entire antenna array, thus

utilizing the full antenna aperture for maximum gain (and hence reduced power requirements for a given required transmission power).

Furthermore, this phased array transmitter configuration is particularly suited for use on a satellite in low earth orbit, where it is desired to maintain a spot beam steadily over a specific ground target for an extended duration, as the satellite ground track moves rapidly. By aligning the antenna array such that the vertical fans lie along the satellite's ground track, the ground target remains within one fan as the satellite travels over it. A signal can be directed to the appropriate fan via the signal router and the Butler matrix, and the spot transmission can be gradually and continually directed down that fan to lock it onto a ground target as the satellite flies over. Fig. 6, and Specification, p. 15, l. 10 – p. 16, l. 4. Thus a primary advantage of and motivating factor for the transmitter configuration of the present invention is its ability to direct a spot beam containing a single signal to a single point on the ground, and maintain the spot over that point for an extended duration as the satellite flies over.

The Examiner rejected claims 1-9, 12-13, 27, 29-32, and 34 under 35 U.S.C. § 103(a) as being unpatentable over Benedicto Ruiz *et al.*, optionally in view of Thompson.[1] U.S. Patent No. 5,648,784 to Benedicto Ruiz discloses a transmitter system for directing one or more beams sequentially over different ground targets, timing the aiming of the beam over each target by the data packets to be transmitted to that target. The system is designed such that the different zones of coverage (i.e., the coverage of each beam when directed to a specific ground target) intersect at least partially so as to delimit a nominal synchronization zone. Within the nominal

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[1] The Examiner stated that the present invention would have been obvious to one of ordinary skill in the art in light of Benedicto Ruiz, "even without Thompson's teaching." Applicant therefore assumes that the disclosure of Thompson is not a necessary element to the Examiner's *prima facie* case of obviousness.

synchronization zone, a ground receiver can either receive packets (when the beam is aimed at it), or at least maintain packet synchronization (when the beam is aimed elsewhere). Benedicto Ruiz, col. 2, ll. 17-49. Benedicto Ruiz thus discloses a form of time-division multiplexing of one signal among multiple geographically dispersed ground targets by "hopping" the transmitted beam from one to the other, the beam hops timed synchronously with the data packets being transmitted. This rapid hopping of the data transmission beam from one ground target to another is precisely the opposite of the mode of operation motivating the design of the present invention – steadily dwelling a data transmission beam on one ground target for as long as possible as the satellite flies over it. Thus, far from rendering the present invention obvious, the transmission system of Benedicto Ruiz teaches away from the present invention.

The structure and configuration of the Benedicto Ruiz transmission system also differ significantly from those of the present invention. Consider Fig. 7. Each modulator MOD_n sources a beamforming network BFN'_n. Each beamforming network sources an array of power amplifiers, which feed the inputs to a p-type Butler matrix. First, one observes that since there is no matrix-forming interconnection among any of the n parallel paths of elements, Fig. 7 most resembles Fig. 4 of the present invention, depicting a prior art configuration of n=4 separate, parallel beamforming and directing circuits, each feeding a part of the array of antenna elements (with the addition of the OMT block that simply reverses the polarization of adjacent antenna element sub-arrays).

Considering one of these *n* parallel legs, the modulator MOD feeds a beamforming network BFN', which is controlled by "a bus BRC deriving from the central

unit OBS, which makes it possible to synchronize the BFN network to the rate of the transmitted temporal multiplexing TDM packets." Benedicto Ruiz, col. 7, ll. 5-8 (referring to Fig. 5, but discussing the same structure as that of Fig. 7). The beamforming network BFN' thus steers the modulated signal among its outputs based on the timing of the data packets to be transmitted. The outputs of the BFN' go through high power amplifiers HPA'_{1-n} and into a Butler matrix MB', which drives the antenna elements A_{1-n}. The Butler matrix MB' directs the signals at its input to different, mutually exclusive lobes or spots of radiated power, via relative phase shifts. Unlike the Butler matrices of the present invention, however, each MB' here will have a signal present only on one of its inputs (or fractionally divided between two adjacent ones), as all its inputs are directly fed from the beamforming network BFN'. The result of this one leg of Fig. 7 is to transmit a beam carrying a single signal in a spot whose radiated direction changes, or hops, based on the timing of the data packets (the BRC bus controlling the beamforming network BFN). The other legs of Fig. 7 merely replicate this action for a plurality of n different signals, each transmitted by a fractional part of the antenna element array.

No one of the *n* signals of Fig. 7 utilize the full antenna aperture of the Benedicto Ruiz system for its transmission, thus none of them is transmitted with the full potential gain of that antenna. More significantly, however, no two-dimensional directional control of any single signal is possible, as there is no 2-D structural matrix to support such control. In the present invention (see Fig. 5), <u>each</u> beamformer feeds one input of <u>every</u> Butler matrix. Conversely, <u>each</u> Butler receives signals from <u>every</u> beamformer. Thus, by routing signals to the Butler matrix inputs via the signal router (to select a fan)

and by steering a spot within a fan by a beamformer's steering control, the spot carrying each signal can be controlled in two dimensions. Additionally, this interconnected structural configuration lends the full gain of the entire antenna aperture to each signal spot. Benedicto Ruiz teaches away from such a system, both in its disclosed structure, and in its application. The disclosure of Benedicto Ruiz was relied upon as the foundation for multiple claim rejections, in combination with various other references cited as teaching specific elements not disclosed in Benedicto Ruiz. None of these rejections present a *prima facie* case of obviousness.

The Examiner rejected claims 14-22 and 25-26 under 35 U.S.C. § 103(a) as being unpatentable over Roederer in view of admitted prior art. U.S. Patent No. 5,115,248 to Roederer discloses a multibeam antenna feed device in which two or more antenna elements are shared among overlapping beams. Roederer, col. 4, ll. 5-10. *See also*, Fig. 1A, depicting nine beams emitted by an array of sixteen antenna elements, each beam sharing four elements. To achieve the shared-element beam forming and aiming, each of the input signals of Roederer are connected to all of the outputs of the beamforming network. This arrangement is depicted in Fig. 3, showing all nine inputs $B_1 \ldots B_9$ connected through beamforming network 5, and then feeding power amplifiers 4. Roederer, col. 6, ll. 19-27. Hence, each power amplifier 4 necessarily amplifies all input signals $B_1 \ldots B_9$. This is precisely the configuration that the present invention avoids – in the present invention, each power amplifier amplifies only a single signal, thus avoiding intermodulation distortion. This configuration of each input feeding every amplifier is depicted throughout Roederer; see Figs. 3, 5, 6B, 22, 23, 24B, 24C, 25B, 26B, 27B, 28B, and 29B.

Claim 14 recites a structure analogous to that of claim 1, having 2*n* signal inputs, and wherein each of *n* beamformers receives two signals of different polarizations. The disclosure of Roederer that teaches the use of two polarizations is Fig. 23 and the explanatory text at col. 9, ll. 15-34. This structure explicitly distributes each input signal (or beam) to every amplifier. "In this case also <u>each</u> beam uses <u>all</u> of the 24 identical power amplifiers 42." Roederer, col. 9, ll. 22-23 (emphasis added). This is precisely the structure of the prior art system depicted in the present application at Fig. 2, and discussed at p. 8, l. 21 – p. 10, l. 2. Note particularly p. 9, ll. 9-16, discussing how this arrangement causes intermodulation distortion. Since Roederer discloses, at most, a structure extensively discussed as prior art in the present application, Roederer cannot render obvious the novel matrix structure of the present invention, wherein each amplifier receives only a single input signal.

The Examiner also rejected claims 38-39 under 35 U.S.C. § 103(a) as being unpatentable over Gross, optionally in view of Wang. U.S. Patent No. 5,977,907 to Gross discloses a satellite phased array antenna that alters the size and shape of each of multiple beams to encompass only the terrestrial-based subscribers with whom communications are necessary at any given time. Gross describes the ability to shape a circular or elliptical beam:

> The main beam footprint can be <u>constricted or broadened</u> in order to encompass the area occupied by the terrestrial-based subscribers. In the case of an elliptical main beam, the orientation of the ellipse, as well as the lengths of the major and minor axes, can be adjusted in order to encompass the area occupied by the group of terrestrial-based subscribers.
>
> Gross, col. 3, ll. 50-55 (emphasis added).

The process of shaping the beams is outlined in the flowchart of Fig. 5, and described at col. 4, ll. 39-65. Gross determines the required geographic extent of the beam, maximizes the gain at the beam centroid, and checks that the minimum gain is present at the required outer boundary of the beam. The subscriber directions are then updated to retarget the customized beam, to compensate for satellite motion.

As discussed above, the matrix structure of the transmission system of the present invention not only minimizes intermodulation distortion, it arranges a plurality of beams into elongated "fans" in first direction, with each fan radiated at a different angle from the others in a second direction. Within each fan, a spot beam may be independently steered longitudinally along the fan (*i.e.*, in the first direction). In use, the array is oriented such that the fans lie along the direction of the satellite's ground track. Input signals are directed to one of the available fans that cover the ground target, and the spot beam for each target is then independently steered along its fan to maintain or dwell the beam over the target as the satellite flies over it. See Fig. 6. According to the present invention, the beams do not change shape or size to include a variable number of targets – they are only steered along their respective fans to maintain coverage as the satellite flies over the ground target. Coverage of geographically separated ground targets is accomplished by directing the relative input signal into the proper fan via a signal router. The present invention, in particular claim 38, is thus distinct from – and nonobvious over – the resizable beams of Gross.

For the forgoing reasons, claims 1, 14, 27, 34, 36, and 38 are patentably nonobvious over the cited art. The rejected dependent claims include all limitations of

their respective parent claims, and are thus also patentably distinguished over the art.

Prompt allowance of all pending claims is therefore respectfully requested.

Respectfully submitted,
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